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AIRS DATA ASSIMILATION AT THE SPoRT CENTER

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AIRS Science Team Meeting – March 2006

transitioning unique NASA data and research technologies to the NWS

Presentation Outline

- SPoRT overview
- Recap of SPoRT AIRS profile assimilation results presented at September 2005 AIRS Science Team Meeting
- New case study (w/ v4.7 profile assimilation)—impact on analysis and forecast and comparison with v4.0
- Future plans with AIRS profiles and radiances

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NASA's Short-term Prediction and Research Transition (SPoRT) Center

Mission: Apply NASA measurement systems and unique Earth science research to improve the accuracy of short-term (0-24 hr) weather prediction at the regional and local scale (http://weather.msfc.nasa.gov/sport/)

Test-bed for rapid prototyping of new products

Transition research capabilities / products to operations

- real-time MODIS data and products to 6 NWS forecast offices
- twice daily WRF model output (initialized with MODIS SSTs)- operational
- convective initiation / lightning products for nowcasting severe weather

Development of new products and capabilities for transition

- MODIS SST composites, AMSR-E rain rates, and ocean color products
- assimilation of AIRS radiances and thermodynamic profiles into regional forecast models

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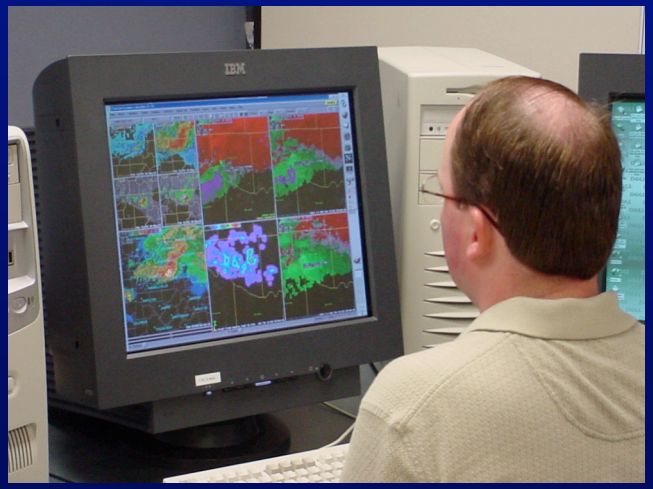
Motivation / Relevance of SPoRT

SPoRT activities are problem driven

- apply Earth science technologies to regional weather studies

Focus on:

- nowcasting – lightning, CI, diagnose visibility and ceiling for aviation
- advanced modeling and data assimilation – MODIS and AIRS in WRF – regional as opposed to global applications addressed by JSCDA / GMAO
- MODIS and AMSR-E data and products



Relevant to several key NASA Earth science questions

- improvements in weather forecasting
- regional air quality impacts
- relationship between weather and climate variability

Direct connections to areas on National Applications

- water and air quality
- disaster coastal management
- aviation

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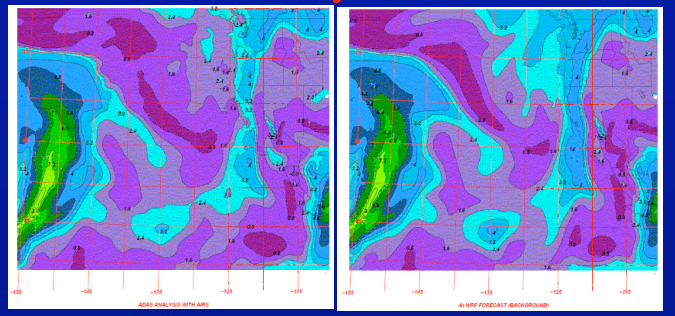
AIRS Profile Assimilation in Regional Models

Straight-forward way to have AIRS affect forecasts

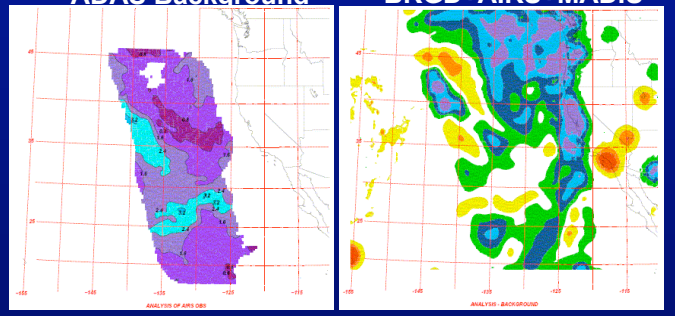
AIRS Science Team Meeting (Sept. 2005)

- described use of QIs in v4.0 in the ADAS/WRF system
- AIRS v4.0 retrievals had a positive impact on 0-48h regional forecast for west coast U.S. case study
  - treat AIRS profiles similar to RAOB
  - tune ADAS 3D influence parameters for AIRS
  - use QIs to eliminate some profiles and to assign weight of data influence
- need for more (refined) quality indicators
  - moisture QIs separate from temperature
  - better vertical delineation in quality

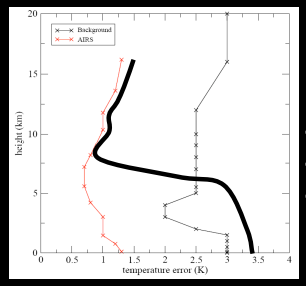
AIRS assimilated at 2200UTC on 14 January 2004



ADAS Background | BKGD+AIRS+MADIS



AIRS analysis | Impact of DA



Example error profile for ADAS for AIRS data failing low-level temperature check

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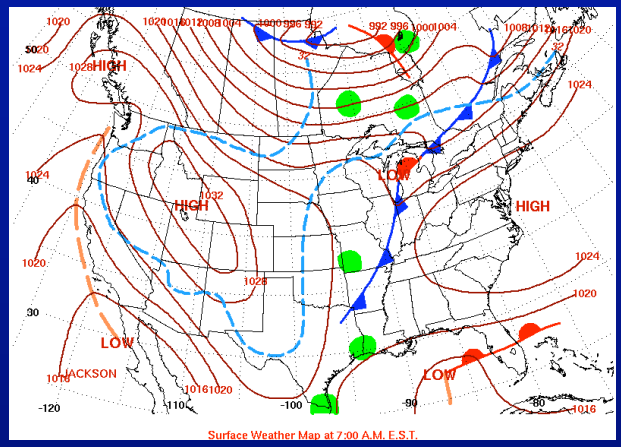
New Case Study: November 20-22, 2005

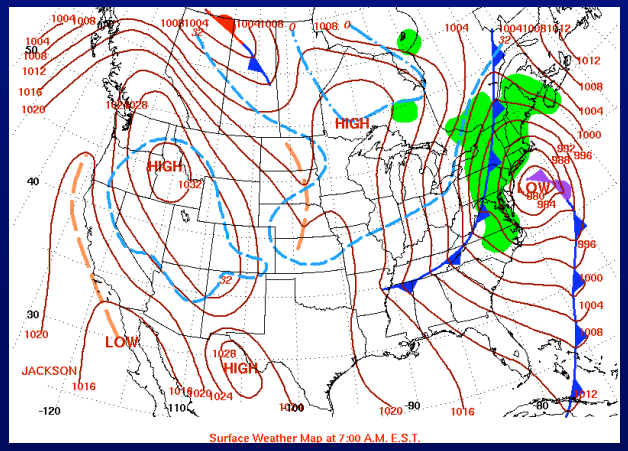
Rapidly intensifying storm off the eastern seaboard poorly forecasted by GFS, NAM, and SPoRT operational WRF

Case Selection

- relevant to SPoRT interests in SEUS region
- more verification data available over the Eastern US (minimal terrain impact)
- synoptic setting
- opportunity to eventually test both over-ocean and over-land AIRS profiles (current case study focuses solely on over-ocean retrievals)
- comparable CONUS domain to operational SPoRT WRF for easy transfer to operations



Surface analysis 11/20/05 12Z



Surface analysis 11/22/05 12Z

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AIRS Data Overview

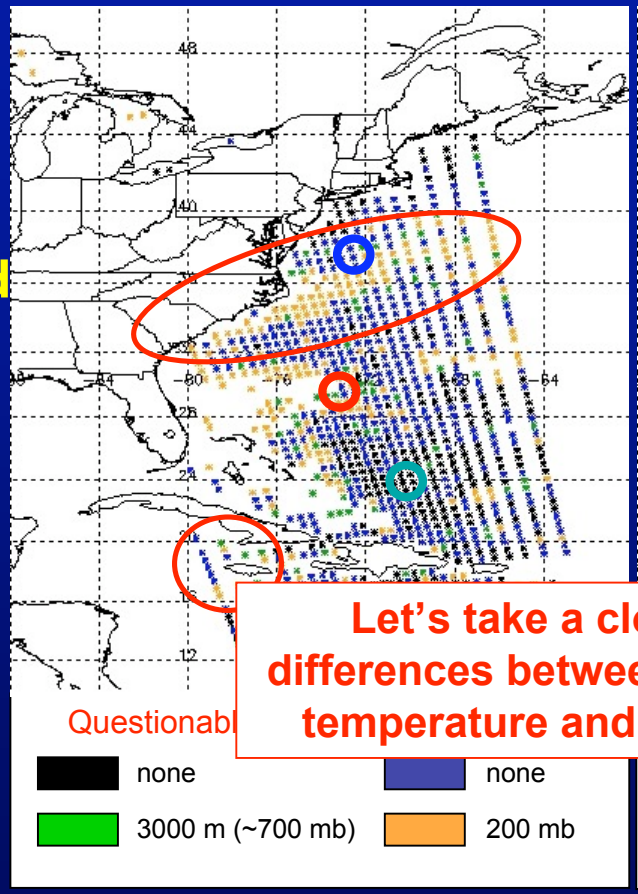
QI improvements in v4.7:

- pressure for each sounding indicating level of valid data
- level-by-level error estimates for each T and q profile

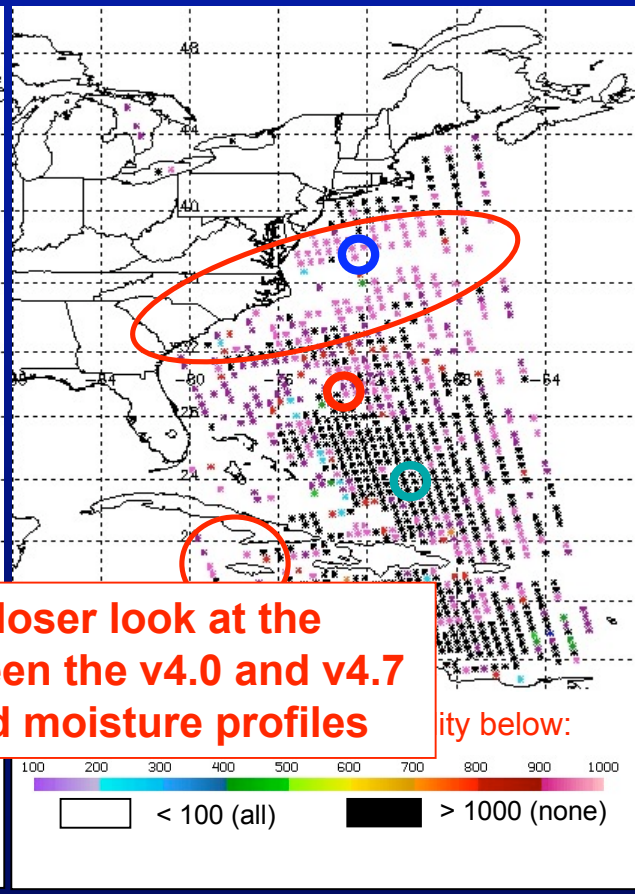
More data are assimilated

- number of assimilated profiles reduced in v4.7
- however, higher data volume as more data are used in the mid-troposphere (previously ambiguous QI here)
- assimilating a larger volume of higher quality data should produce an analysis that provides <u>better initial conditions for the WRF</u>

Version 4.0



Version 4.7



Let's take a closer look at the differences between the v4.0 and v4.7 temperature and moisture profiles

963 AIRS profiles assimilated

797 AIRS profiles assimilated

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v4.0/v4.7 AIRS Profile Comparison

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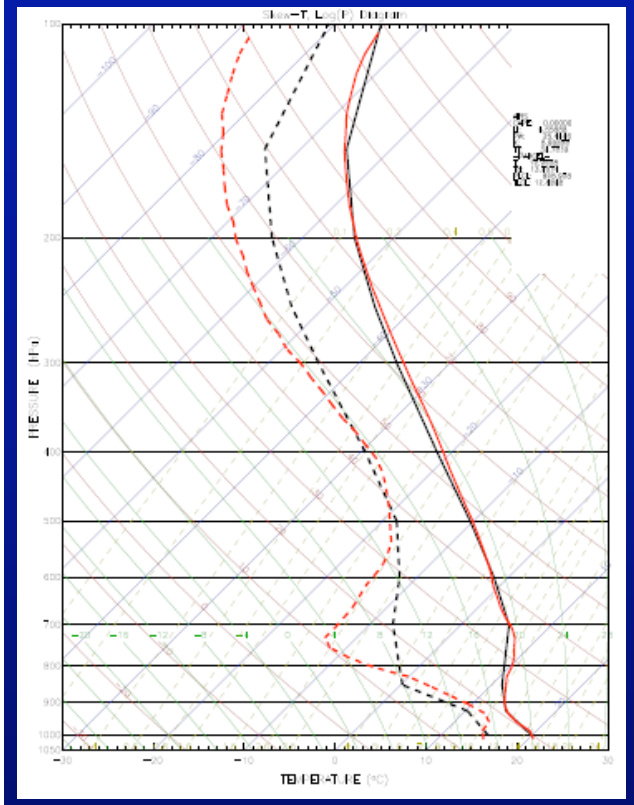
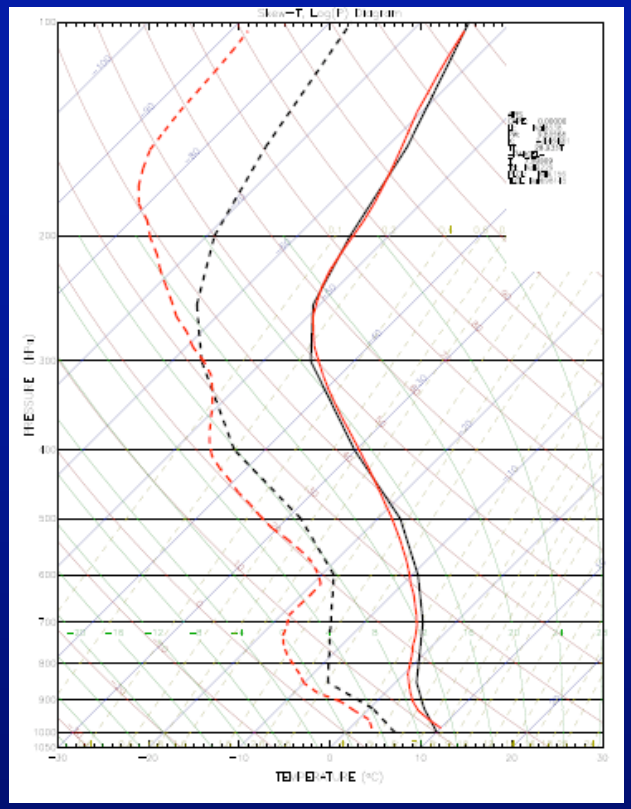
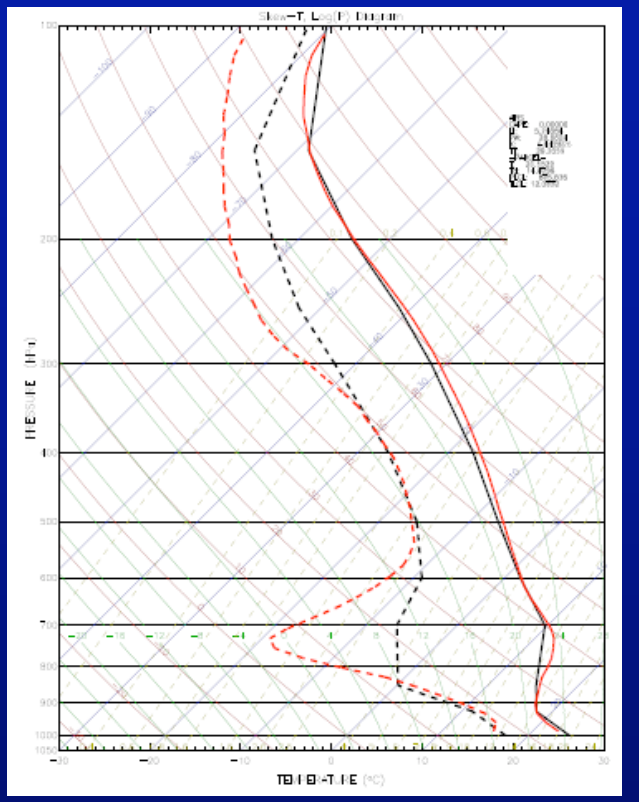


30.512°N, 72.342°W (RED circle)



38.961°N, 72.389°W (BLUE circle)



24.364°N, 69.991°W (GREEN circle)

Black: v4.0 (standard; 12 levels) Red: v4.7 (supplemental; ≈53 levels)

- Small change in T but significant q reduction (drying) in the mid-troposphere (evident even with different vertical resolution)
- Changes made to the water vapor regression step

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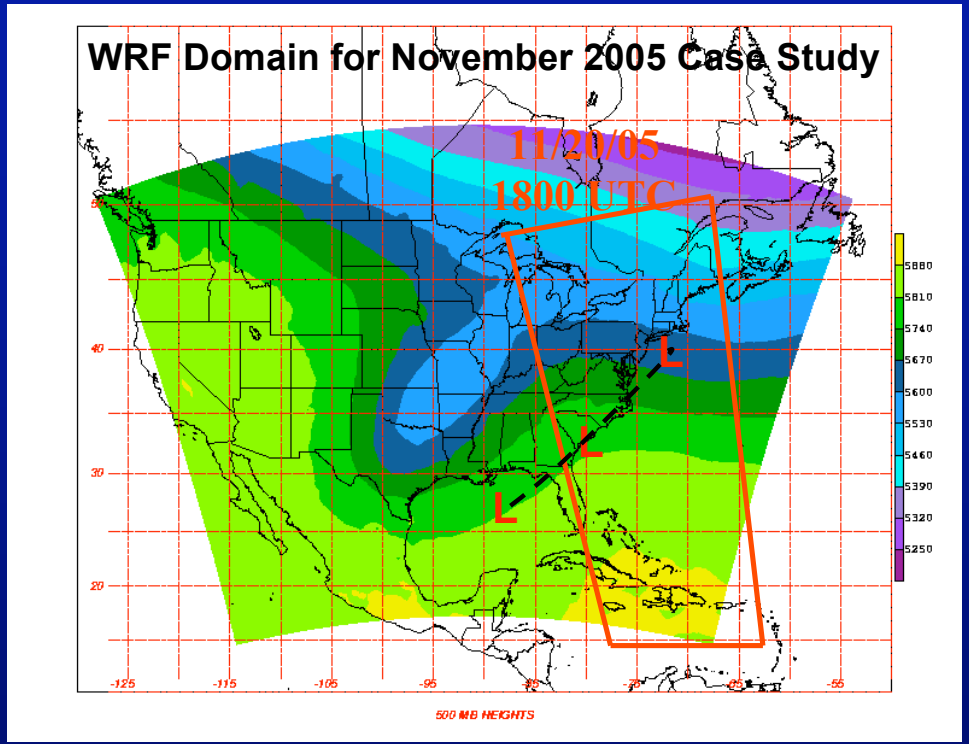
SPoRT Research WRF and Analysis

WRF Configuration

- 36km domain with 37 vertical levels
- state-of-the-art dynamics and physics
- initialized with NCEP 1° GFS grids, with 6-h forecasts used as LBC

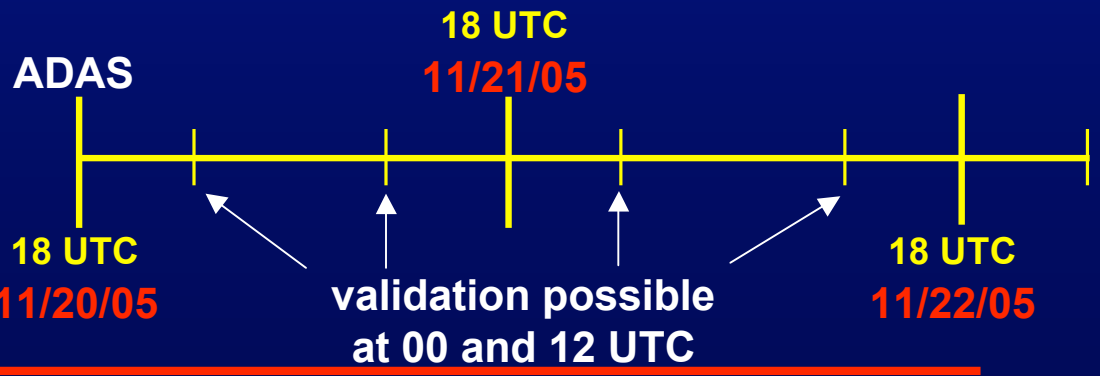
ADAS Configuration

- same resolution as WRF (43 vertical levels)
- Bratseth SCM weights obs using horizontal and vertical ROIs and error characteristics
- error table for each data: AIRS errors are from v4.0 documentation (≈1/3 of BKGD)
- sufficient vertical scaling to account for the difference in vertical resolution of AIRS soundings



Assimilation / Forecast

- GFS interpolated to WRF domain
- WRF analysis at 18 UTC used as background for ADAS



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AIRS DA for 700 mb Mixing Ratio

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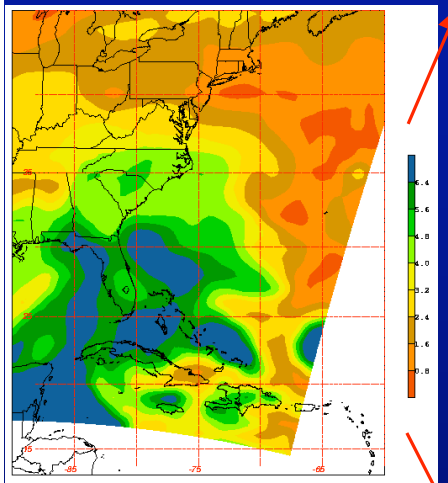
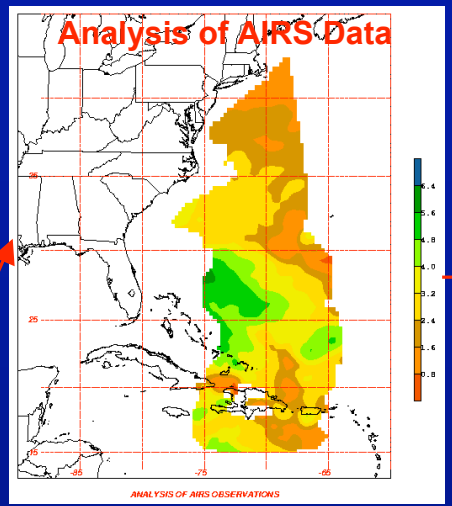
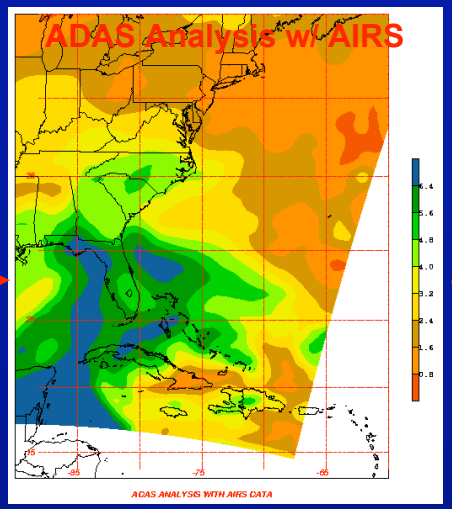
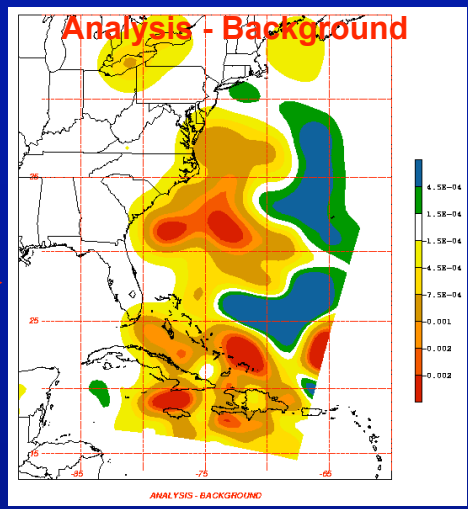
v4.0



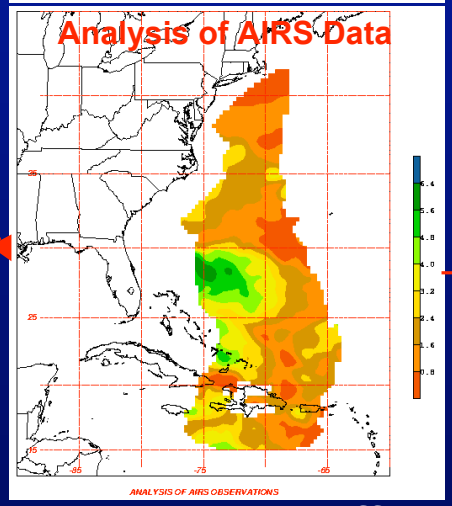
WRF Background at 18 UTC

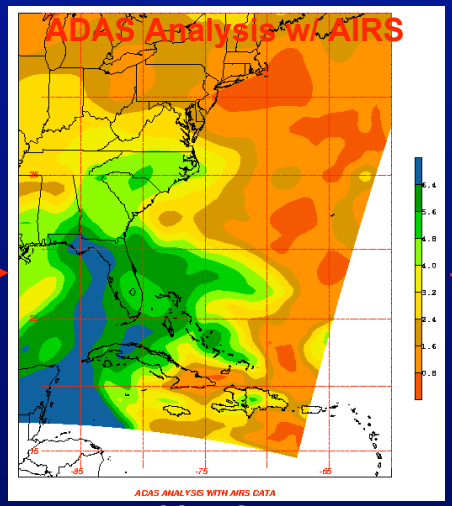


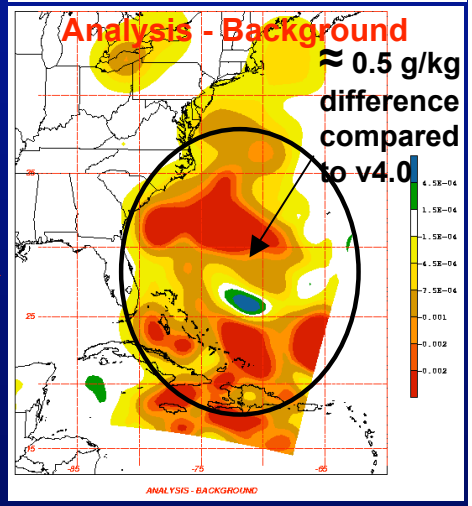




v4.7







- significant analysis/background differences (≈ 20% of total q at 700 mb)
- v4.7 analysis is ≈0.5 g/kg drier than the v4.0 throughout most of the AIRS swath
- difference between v4.7 and v4.0 impact on temperature analysis field generally smaller

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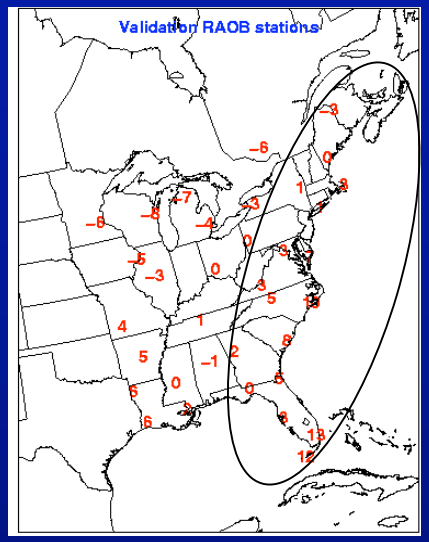
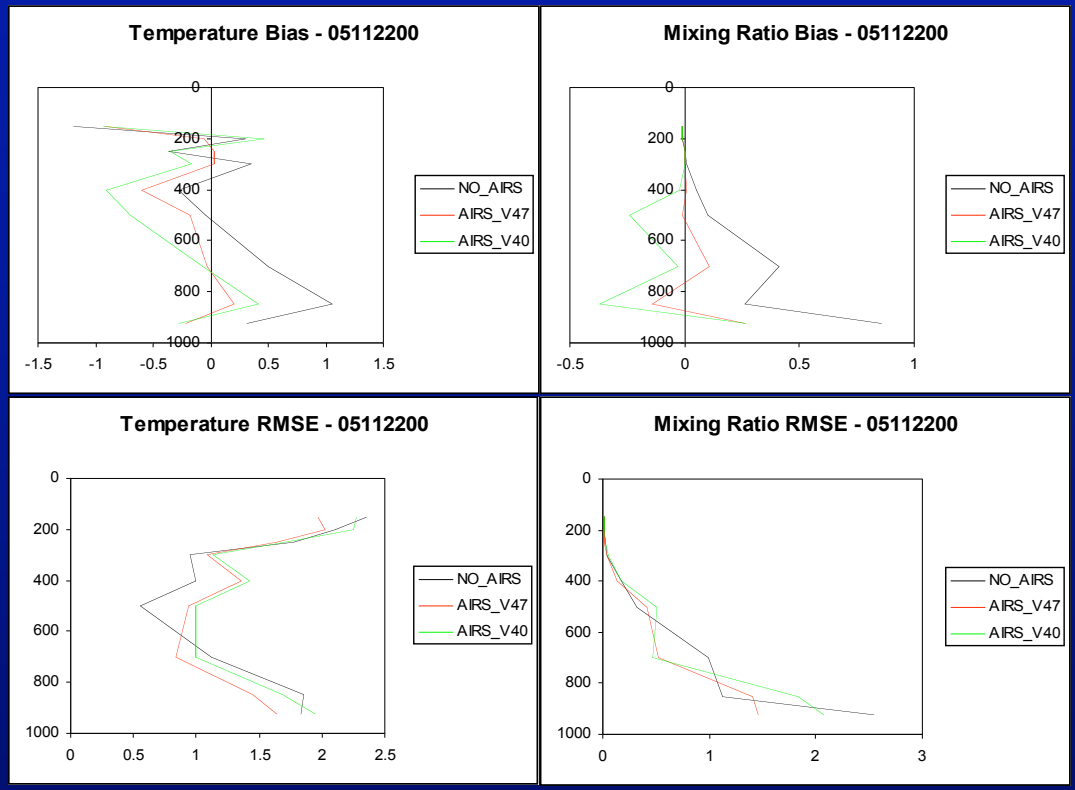
30h Forecast Validation Against RAOBs



Validated against 17 east coast RAOBs



- inclusion of v4.7 AIRS data reduces bias in T and q at most levels
- RMS error is smaller for T below 600 mb with v4.7 data; control performs better above 600 mb
- RMS error improvements for q are mixed with AIRS improving forecast in mid-troposphere

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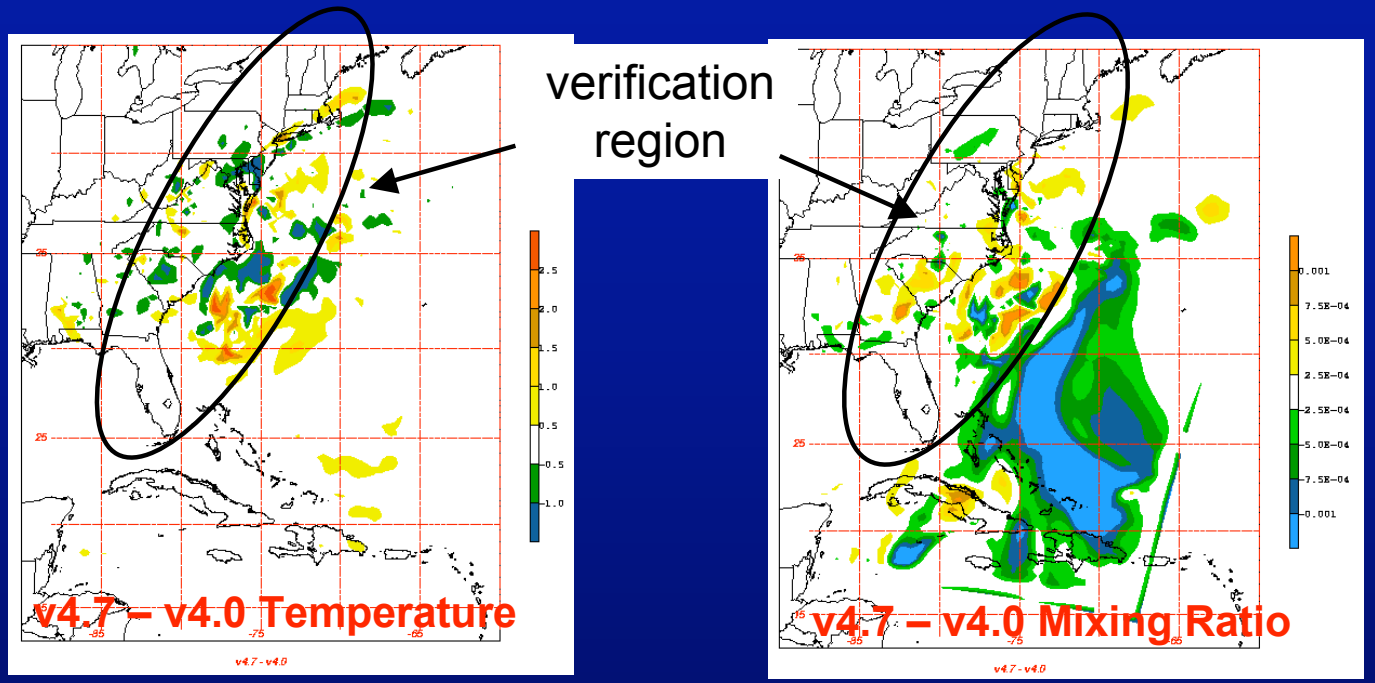
30h Forecast Intercomparison

700 mb T and q



v4.7 vs. v4.0 forecast verification impact on RMSE greater for T but q significantly impacts forecast outside validation region

- **±1° temperature differences over many parts of coastline where verification occurs**
- **largest differences (> 1 g/kg) in moisture field occur outside verification region**

November 2005 Case Study Summary

New level-specific QIs for v4.7 provide a larger volume of higher quality data for assimilation

v4.7 data improve the 30h forecast of T and q compared to RAOBs

- forecast bias improves over control and v4.0 for both T and q at most levels
- forecast RMS significantly improves over the control and v4.0 for T below 600 mb; RMS results are mixed for q in validation region
- improvements are likely due to improved moisture regression and more specific QIs in the v4.7 data

Future plans involving AIRS

- developing case-specific error tables for ADAS using a statistical representation of the individual profile error estimates in the new v4.7 data
- assimilation of AIRS radiance data on regional scale

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Radiance Data Assimilation into Regional Models

Direct way to have AIRS data affect short term weather forecasts

Use state-of-the-art WRF modeling system

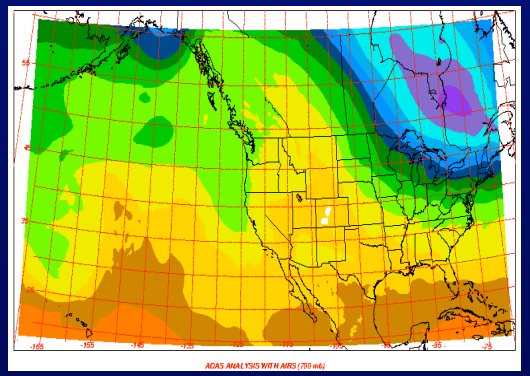
- future NCEP operational system
- data assimilation using Gridpoint Statistical Interpolation (GSI) – 3DVAR

GSI supports cloud-free radiance data assimilation

- more direct method than profiles – avoids retrieval problems
- single field of view data
- existing approach with GOES / TOVS
- consider cloud-cleared radiances – quality? - data volume?

Problems with this approach:

- data volume – large even on a regional scale
  - "super obs" - brute force, not necessarily the best
  - need intelligent data thinning – based on weather of the day
- need to identify cloud-free radiances
  - based on channel not cloud mask



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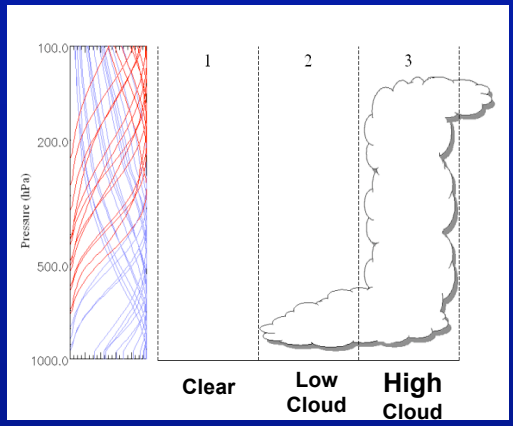
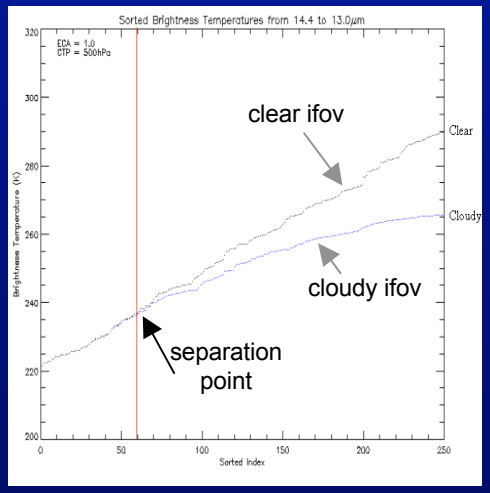
Detection of Clear / Cloudy Radiances

Cloud mask used to identify clear-cloudy AIRS ifovs

- if cloudy throw away all radiance data
- 5-10% clear AIRS ifovs – usually not meteorologically significant regions
- need to identify cloud contamination by channel





Use CO2 sorting approach to explicitly identify channels contaminated by clouds

- sort data by brightness temperature
- determination of the separation point between contaminated and uncontaminated channels
  - position of the separation point is a function of CTP
  - magnitude of the separation is a function of ECF
- clear scene is dependant on a background field

Impact:

- 2-3 factor increase in radiances (over masking approach)
- Data added in meteorologically significant regions (above clouds)

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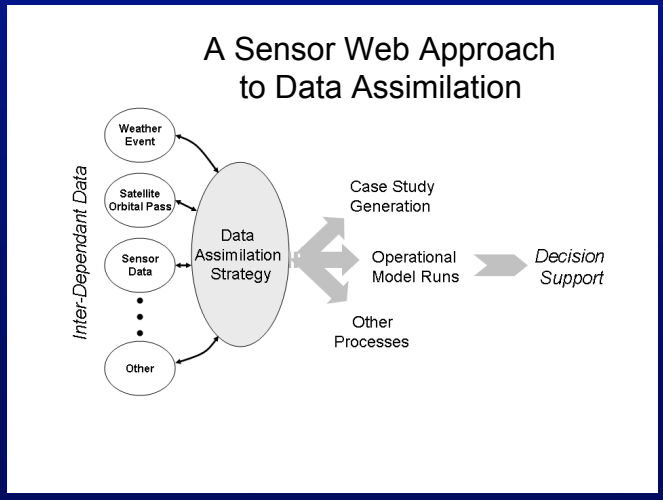
Towards Operational Assimilation of AIRS Data on a Regional Scale

Develop operational capability for real-time AIRS data assimilation as supplemental forecasts for NWS WFOs in Southeast U.S.

- ADAS/WRF with AIRS profiles in FY06-FY07
- GSI / WRF – cloud-free radiances in FY07-FY08

Considerations:

- real-time AIRS availability
- sensor web capabilities for autonomous operations—select forecast/assimilation cycle based on:
  - anticipated weather (high impact events)
  - juxtaposition of AIRS pass w.r.t. the storm feature of interest
  - other ancillary data
- intelligent data thinning



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